

6:915-922 (1988)) which encodes glyphosate resistance; a nitrilase gene which confers resistance to bromoxynil (Stalker et al., *J. Biol. Chem.* 263:6310-6314 (1988)); a mutant acetolactate synthase gene (ALS) which confers imidazolinone or sulphonylurea resistance (European Patent Application 154,204 (Sep. 11, 1985)); and a methotrexate resistant DHFR gene (Thillet et al., *J. Biol. Chem.* 263:12500-12508 (1988)).

[0136] A recombinant vector or construct of the present invention may also include a screenable marker. Screenable markers may be used to monitor expression. Exemplary screenable markers include a β -glucuronidase or uidA gene (GUS) which encodes an enzyme for which various chromogenic substrates are known (Jefferson, *Plant Mol. Biol. Rep.* 5:387-405 (1987); Jefferson et al., *EMBO J.* 6:3901-3907 (1987)); an R-locus gene, which encodes a product that regulates the production of anthocyanin pigments (red color) in plant tissues (Dellaporta et al., *Stadler Symposium* 11:263-282 (1988)); a β -lactamase gene (Sutcliffe et al., *Proc. Natl. Acad. Sci. (U.S.A.)* 75:3737-3741 (1978)), a gene which encodes an enzyme for which various chromogenic substrates are known (e.g., PADAC, a chromogenic cephalosporin); a luciferase gene (Ow et al., *Science* 234:856-859 (1986)) a xylE gene (Zukowsky et al., *Proc. Natl. Acad. Sci. (U.S.A.)* 80:1101-1105 (1983)) which encodes a catechol dioxygenase that can convert chromogenic catechols; an α -amylase gene (Ikata et al., *Bio/Technol.* 8:241-242 (1990)); a tyrosinase gene (Katz et al., *J. Gen. Microbiol.* 129:2703-2714 (1983)) which encodes an enzyme capable of oxidizing tyrosine to DOPA and dopaquinone which in turn condenses to melanin; an α -galactosidase, which will turn a chromogenic α -galactose substrate.

[0137] Included within the terms "selectable or screenable marker genes" are also genes which encode a secretable marker whose secretion can be detected as a means of identifying or selecting for transformed cells. Examples include markers which encode a secretable antigen that can be identified by antibody interaction, or even secretable enzymes which can be detected catalytically. Secretable proteins fall into a number of classes, including small, diffusible proteins detectable, e.g., by ELISA, small active enzymes detectable in extracellular solution (e.g., α -amylase, β -lactamase, phosphinothricin transferase), or proteins which are inserted or trapped in the cell wall (such as proteins which include a leader sequence such as that found in the expression unit of extension or tobacco PR-S). Other possible selectable and/or screenable marker genes will be apparent to those of skill in the art.

[0138] In addition to a selectable marker, it may be desirable to use a reporter gene. In some instances a reporter gene may be used with or without a selectable marker. Reporter genes are genes which are typically not present in the recipient organism or tissue and typically encode for proteins resulting in some phenotypic change or enzymatic property. Examples of such genes are provided in K. Wising et al. *Ann. Rev. Genetics*, 22, 421 (1988), which is incorporated herein by reference. Preferred reporter genes include the beta-glucuronidase (GUS) of the uidA locus of *E. coli*, the chloramphenicol acetyl transferase gene from Tn9 of *E. coli*, the green fluorescent protein from the bioluminescent jellyfish *Aequorea victoria*, and the luciferase genes from firefly *Photinus pyralis*. An assay for detecting reporter gene expression may then be performed at a suitable time after said gene has been introduced into recipient cells. A preferred such assay entails

the use of the gene encoding beta-glucuronidase (GUS) of the uidA locus of *E. coli* as described by Jefferson et al., (1987 *Biochem. Soc. Trans.* 15, 17-19) to identify transformed cells.

[0139] In preparing the DNA constructs of the present invention, the various components of the construct or fragments thereof will normally be inserted into a convenient cloning vector, e.g., a plasmid that is capable of replication in a bacterial host, e.g., *E. coli*. Numerous vectors exist that have been described in the literature, many of which are commercially available. After each cloning, the cloning vector with the desired insert may be isolated and subjected to further manipulation, such as restriction digestion, insertion of new fragments or nucleotides, ligation, deletion, mutation, resection, etc. so as to tailor the components of the desired sequence. Once the construct has been completed, it may then be transferred to an appropriate vector for further manipulation in accordance with the manner of transformation of the host cell.

[0140] A recombinant vector or construct of the present invention may also include a chloroplast transit peptide, in order to target the polypeptide or protein of the present invention to the plastid. The term "plastid" refers to the class of plant cell organelles that includes amyloplasts, chloroplasts, chromoplasts, elaioplasts, eoplasts, etioplasts, leucoplasts, and proplastids. These organelles are self-replicating, and contain what is commonly referred to as the "chloroplast genome," a circular DNA molecule that ranges in size from about 120 to about 217 kb, depending upon the plant species, and which usually contains an inverted repeat region. Many plastid-localized proteins are expressed from nuclear genes as precursors and are targeted to the plastid by a chloroplast transit peptide (CTP), which is removed during the import steps. Examples of such chloroplast proteins include the small subunit of ribulose-1,5-biphosphate carboxylase (ss-RUBISCO, SSU), 5-enolpyruvateshikimate-3-phosphate synthase (EPSPS), ferredoxin, ferredoxin oxidoreductase, the light-harvesting-complex protein I and protein II, and thioredoxin F. It has been demonstrated that non-plastid proteins may be targeted to the chloroplast by use of protein fusions with a CTP and that a CTP sequence is sufficient to target a protein to the plastid. Those skilled in the art will also recognize that various other chimeric constructs can be made that utilize the functionality of a particular plastid transit peptide to import the enzyme into the plant cell plastid depending on the promoter tissue specificity.

[0141] The present invention also provide a transgenic plant comprising in its genome an isolated nucleic acid which comprises: (A) a 5' non-coding sequence which functions in the cell to cause the production of a mRNA molecule; which is linked to (B) a structural nucleotide sequence, wherein the structural nucleotide sequence encodes a *D. v. virgifer* proteins or fragments thereof; which is linked to (C) a 3' non-translated sequence that functions in said cell to cause termination of transcription.

[0142] The term "transgenic plant" refers to a plant that contains an exogenous nucleic acid, which can be derived from the same plant species or from a different plant species. Transgenic plants are also meant to comprise progeny (decendant, offspring, etc.) of any generation of such a transgenic plant. A seed of any generation of all such transgenic plants wherein said seed comprises a DNA sequence encoding the protein or fragment thereof of the present invention is also an important aspect of the invention.